CLAIMS

We claim:

1. A method for excising narrowband interference, the method comprising the steps of:

   a) transforming time domain data into a frequency domain vector having a plurality of frequency bins;

   b) estimating a plurality of power values corresponding to frequency bins of said frequency domain vector to obtain a current power vector;

   c) calculating an average power vector from said current power vector and at least one selected previous power vector;

   d) excising selected frequency bins of said frequency domain vector to produce an excised frequency domain vector;

   e) determining whether to include said average power vector in future average power vector determinations.

2. The method of Claim 1, wherein said calculating said average power vector step (c) of Claim 1 comprises the following sub-steps:

   i) determining a power scale factor vector based on power values of frequency bins of said current power vector;

   ii) calculating said average power vector from said current power vector and said at least one selected previous power vector;

   iii) calculating a scaled power vector from said current power vector and said power scale factor vector;

   iv) storing said current power vector.

3. The method of Claim 2, wherein said determining said power scale factor vector sub-step (i) of Claim 2 comprises the following sub-steps:

(1) determining whether said power value of said current power vector associated with a frequency bin is less than a threshold;

(2) if said power value of said current power vector associated with said frequency bin is less than a threshold, setting a power scale factor associated with said frequency bin to a number of blocks used for averaging, else setting said power scale factor associated with said frequency bin to 1;

(3) repeating steps (1) and (2) until said power scale factor vector comprising a plurality of power scale factors is calculated.

4. The method of Claim 2, wherein said calculating said scaled power vector sub-step (iii) of Claim 2 comprises multiplying said current power vector by said power scale factor vector.

5. The method of Claim 2, wherein said storing said power vectors sub-step (iv) of Claim 2 comprises the following sub-steps:

(1) rescaling said scaled power vector to obtain said current power vector;

(2) storing said current power vector.

6. The method of Claim 5, wherein said rescaling sub-step (1) of Claim 5 comprises dividing said scaled power vector by said power scale factor vector.

7. The method of Claim 2, wherein said storing said current power vector sub-step (iv) of Claim 2 comprises the following sub-steps:

(1) obtaining said current power vector from said estimating a plurality of power values step (b) of Claim 1;

(2) storing said current power vector.

8. The method of Claim 1, wherein said calculating said average power vector step (c) of Claim 1 comprises the following sub-steps:

i) determining a power scale factor vector based on power values of frequency bins of said current power vector;

ii) calculating a scaled power vector from said current power vector and said power scale factor vector;

iii) calculating said average power vector from said current power vector and said at least one selected previous power vector;

iv) storing said current power vector.

9. The method of Claim 1, wherein said determining whether to include said average power vector from future average power vector determinations step (e) of Claim 1 comprises the following sub-steps:

i) calculating a current excision percentage from an excision flag vector;

ii) determining whether said current power vector should be excised from future calculations of said average power vector based on a ratio between said current excision percentage and a previous excision percentage.

10. The method of Claim 9, wherein said determining sub-step (ii) of Claim 8 comprises the following sub-steps:

(1) determining whether said current excision percentage is greater than a product of said previous excision percentage multiplied by a threshold;

(2) if said current excision percentage is greater than a product of said previous excision percentage multiplied by a threshold, setting an exceed counter to zero, else incrementing said exceed counter by one and discarding said current power vector from future calculations of said average power vector.

11. The method of Claim 9, wherein said determining sub-step (ii) of Claim 8 comprises the following sub-steps:

(1) determining whether said current excision percentage is greater than a product of said previous excision percentage multiplied by a threshold;

(2) if said current excision percentage is greater than a product of said previous excision percentage multiplied by a threshold, setting an exceed counter to zero and proceeding to step (4) of Claim 10, else incrementing said exceed counter by one;

(3) if said exceed counter is less than a predetermined limit, discarding said current power vector from future calculations of said average power vector, else setting a previous excision flag vector to a current excision flag vector;

(4) proceeding with the method of Claim 1.

12. The method of Claim 9, wherein said determining sub-step (ii) of Claim 8 further comprises setting an excision flag to 1 if said average power vector is to be included in future average power vector determinations.

13. The method of Claim 1, wherein method further comprises the following steps:

f) performing frequency domain to time domain transformation on said excised frequency domain vector to produce a time domain output vector;

g) performing output processing on said time domain output vector to produce a valid output vector.

14. A narrowband interference excision device, comprising:

a) a transformer capable of transforming time domain data to a frequency domain vector comprising a plurality of frequency bins;

b) a power estimator, operatively coupled to said transformer, capable of receiving said frequency domain vector, and adapted to determine a PXW power vector comprising a plurality of power values that correspond to said plurality of frequency bins;

c) a moving average calculator, operatively coupled to said power estimator, capable of receiving said PXW power vector and a discard flag, and adapted to determine an

average power vector;

d) an excisor, operatively coupled to said transformer, capable of receiving said frequency domain vector and said average power vector, and adapted to excise selected frequency bins of said plurality of frequency bins and determine an excised power vector and an excision flag vector;

e) a transient eliminator, operatively coupled to said excisor and said moving average calculator, capable of receiving said excision flag vector, and adapted to determine whether to include said average power vector from future average power vector determinations and determine said discard flag.

15. The narrowband interference excision device of Claim 14, further comprising:

f) an inverse transformer, operatively coupled to said excisor, capable of receiving said excised power vector, and adapted to transform said excised power vector to a time domain output vector;

g) an output processor, operatively coupled to said inverse transformer, capable of receiving said time domain output vector, and adapted to determine a valid time domain output vector.

16. The narrowband interference excision device of Claim 14, wherein said moving average calculator comprises:

i) a power scaling device, operatively coupled to said power estimator, capable of receiving said PXW power vector, and adapted to scale said plurality of power values of said PXW power vector to obtain a scaled power vector;

ii) an average power vector computer, operatively coupled to said power scaling device, capable of receiving said scaled power vector and at least one previous power vector, and adapted to determine an average power vector.

17. The narrowband interference excision device of Claim 16, wherein said power scaling device comprises:

(1) a power scale factor computer, operatively coupled to said power estimator, capable of receiving said PXW power vector, and adapted to determine a power scale factor vector;

(2) a power scaler, operatively coupled to said power scale factor computer, capable of receiving said PXW power vector and power scale factor vector, and adapted to determine a scaled power vector.

18. The narrowband interference excision device of Claim 16, wherein said moving average calculator further comprises:

iii) a current block power rescaler, capable of receiving said discard flag, and adapted to output a current PXW power vector depending on said discard flag;

iv) a previous power block storage device, operatively coupled to said current block power rescaler and said average power vector computer, capable of storing previous PXW power vectors.

19. The narrowband interference excision device of Claim 14, wherein said transient eliminator comprises:

i) an excision percentage calculator, operatively coupled to said excisor, capable of receiving said excision flag vector, and adapted to determine a current excision percentage;

ii) a transient excision device, operatively coupled to said excision percentage calculator, capable of receiving said current excision percentage, and adapted to detect transient conditions based on a ratio between a current excision percentage and a previous excision percentage and adapted to set said discard flag depending on detection of transient conditions.

20. The narrowband interference excision device of Claim 19, wherein said transient excision device sets said discard flag to indicate transient conditions when an exceed counter is less than a predetermined limit.

21. An ELF receiver, comprising:

a) an antenna;

b) a pre-amplifier;

c) an analog-to-digital converter;

d) a narrowband interference excision device, comprising:

i) a transformer capable of transforming time domain data to a frequency domain vector comprising a plurality of frequency bins;

ii) a power estimator, operatively coupled to said transformer, capable of receiving said frequency domain vector, and adapted to determine a PXW power vector comprising a plurality of power values that correspond to said plurality of frequency bins;

iii) a moving average calculator, operatively coupled to said power estimator, capable of receiving said PXW power vector and a discard flag, and adapted to determine an average power vector;

iv) an excisor, operatively coupled to said transformer, capable of receiving said frequency domain vector and said average power vector, and adapted to excise selected frequency bins of said plurality of frequency bins and determine an excised power vector and an excision flag vector;

v) a transient eliminator, operatively coupled to said excisor and said moving average calculator, capable of receiving said excision flag vector, and adapted to determine whether to include said average power vector from future average power vector determinations and determine said discard flag;

e) at least one receiver processing device.